

A photograph taken from the International Space Station (ISS) showing the Earth's surface and the aurora borealis. The aurora is a vibrant green light display in the upper atmosphere, appearing as a horizontal band of light. The ISS structure, including solar panel arrays, is visible in the foreground on the left side of the frame. The Earth's surface below is a mix of dark land and lighter, textured ice or snow.

Space Weather Monitoring for ISS Space Environments Engineering and Crew Auroral Observations

Joseph I. Minow
NASA, Marshal Space Flight Center

Donald R. Pettit
NASA, Johnson Space Center
ISS Expeditions 6, 30/31

William A. Hartman
The Boeing Company

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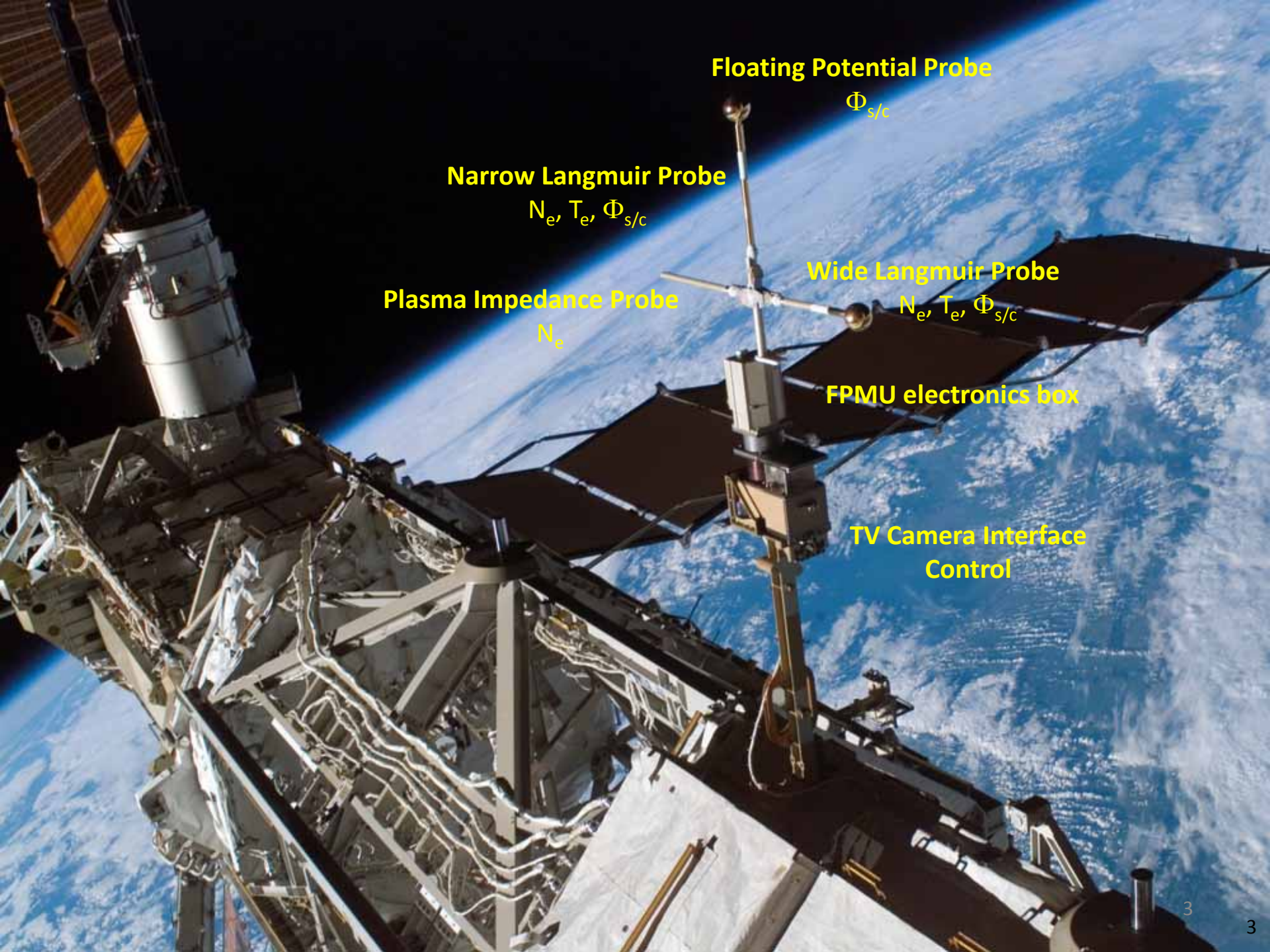


Introduction

Today's presentation describes how real time space weather data is used by the International Space Station (ISS) space environments team to obtain data on auroral charging of the ISS vehicle and support ISS crew efforts to obtain auroral images from orbit

Outline

- Floating Potential Measurement Unit (FPMU)
- Auroral charging of ISS
- Real-time space weather monitoring resources
- Examples of ISS auroral charging captured from space weather events
- ISS crew observations of aurora



Floating Potential Probe

$\Phi_{s/c}$

Narrow Langmuir Probe

$N_e, T_e, \Phi_{s/c}$

Wide Langmuir Probe

$N_e, T_e, \Phi_{s/c}$

Plasma Impedance Probe

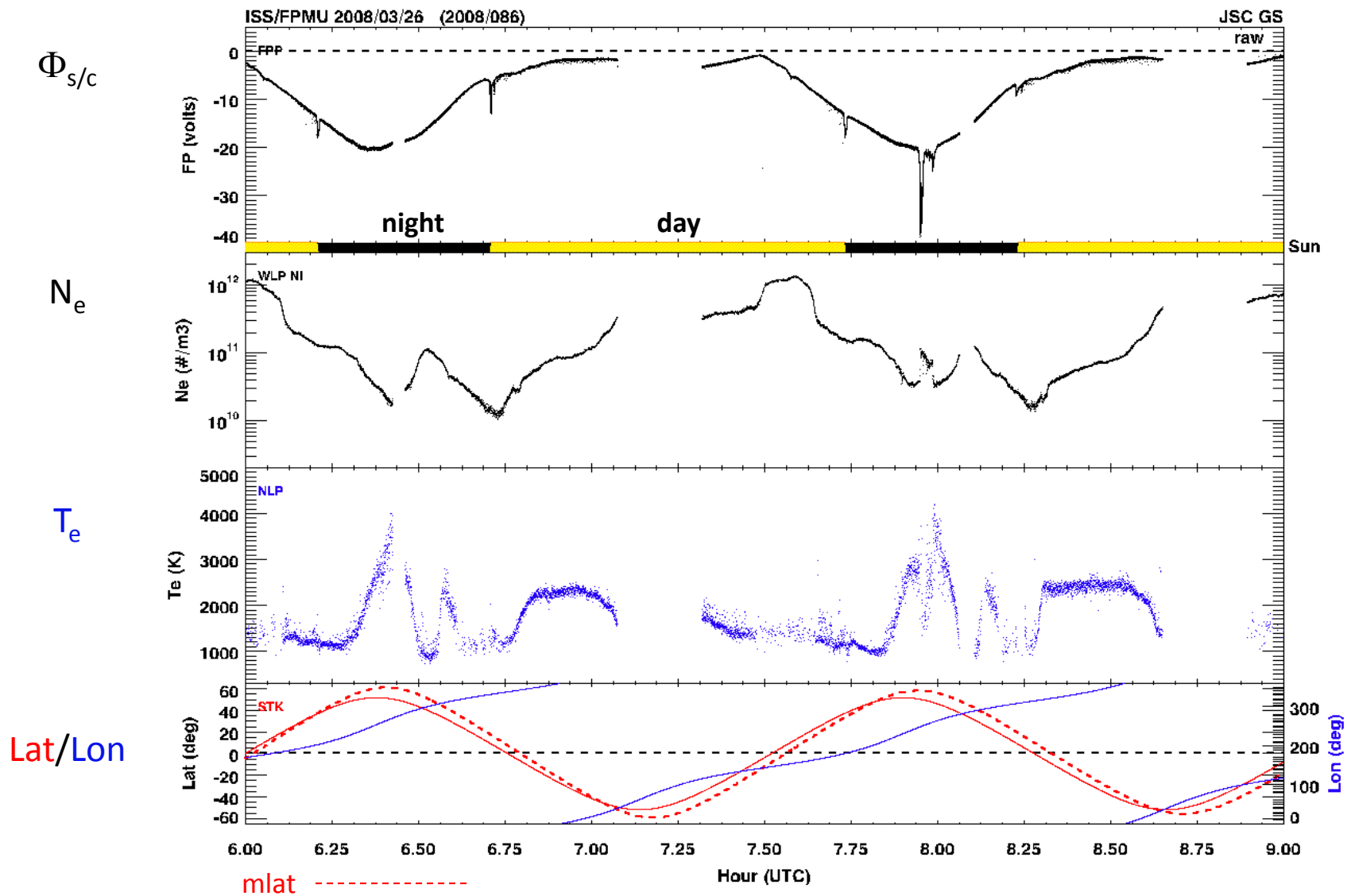
N_e

FPMU electronics box

**TV Camera Interface
Control**

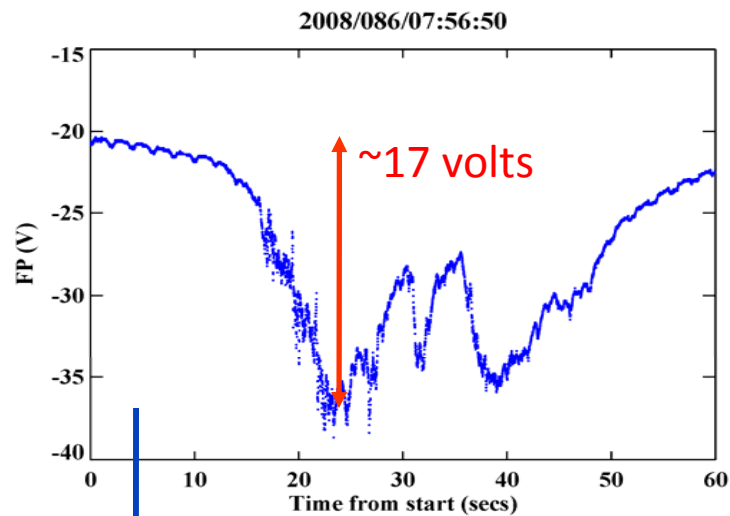


ISS Charging at Night 26 March 2008

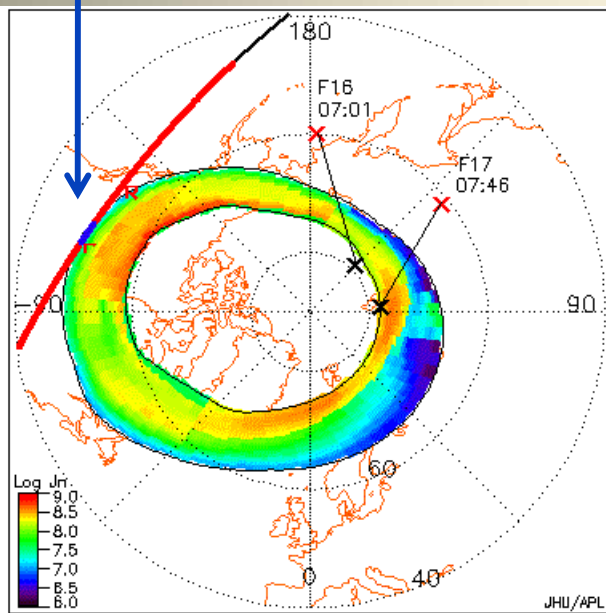
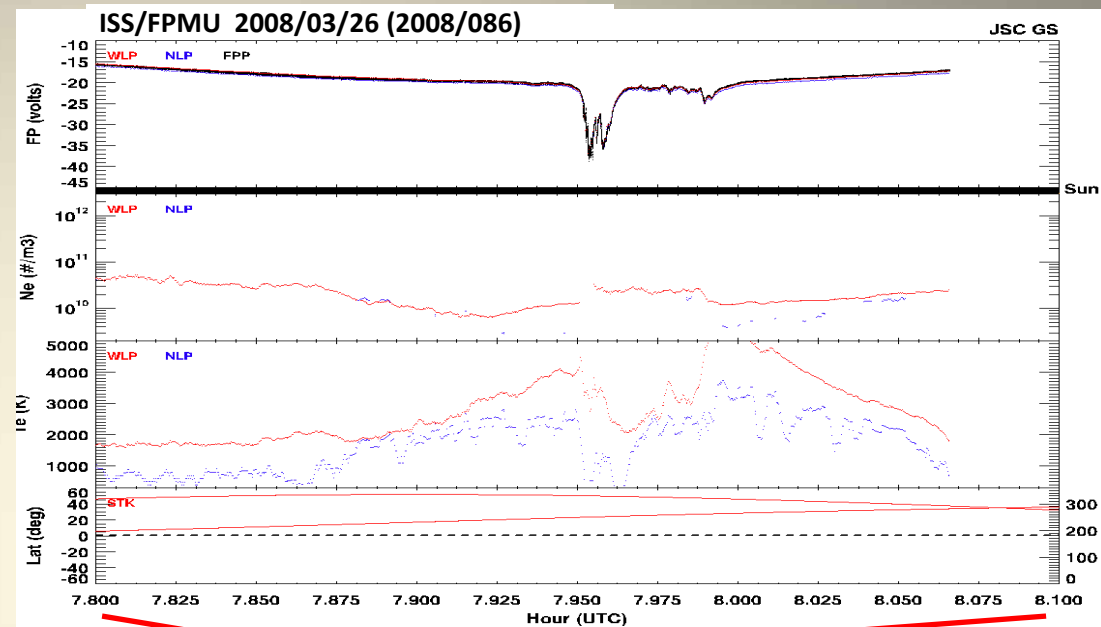




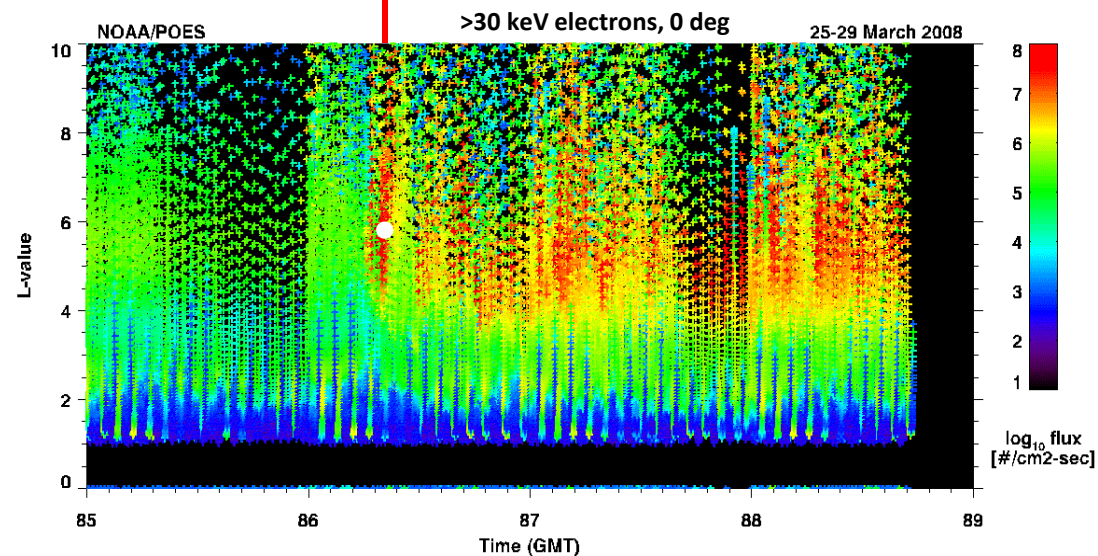
Auroral Charging



26 Mar 2008 07:30 – 08:00 UT



Normalized B2i = 62 Flux = 726 MWb
Equivalent Kp = 3.0 Global e- E-Flux = 23.0 MW



[adapted from Craven *et al.*, 2009]



ISS FPMU Operations

- FPMU data is encoded into a video signal and downlinked in the ISS Ku band telemetry stream
 - Ku band telemetry is a resource shared between ISS operations and science activities
 - Amount of time the TVCIC video box can be operated is restricted
 - FPMU operated on a campaign basis < ~30% of a year for periods of days to few weeks
- Scheduled operations support ISS engineering and science activities:
 - Characterizing ISS 160 V solar array interactions with ionosphere plasma
 - ISS charging due to visiting vehicles
 - US and Russian extravehicular activity (EVA) support
 - ISS science payload support
 - Collaborative ionospheric research with other spacecraft and ground based facilities
 - Incoherent Scatter Radar World Day periods

Space weather is not an issue for scheduled events...
- FPMU is also operated for unscheduled events:
 - Targets of opportunity for collaborating with ISS science payloads, instruments on independent spacecraft, or ground base science operations
 - Anomaly investigations
 - Characterizing ISS auroral charging and ionospheric response to geomagnetic storms

How do we optimize collecting ISS auroral charging and ionospheric storm data when FPMU is only operated on a campaign basis?



Capturing Auroral Charging Data

- Use real time space weather data to target FPMU operations during geomagnetic storm periods when ISS auroral charging is most likely
- Operate FPMU for periods immediately before and a few days after predicted time of geomagnetic storm onset:
 - Space weather alerts for earthward directed CME's give us advanced warning for potentially geoeffective solar events
 - Typically look for fast (≥ 1000 km/s) CME's since they provide the best chance for driving the auroral oval equatorward of the ISS orbit for extended periods of time
 - Activate FPMU in advance of CME arrival if not already in operation

ISS Auroral Charging Observations

FPMU Operations

26 March 2008 (GMT 086)

STS-123/ESA ATV-001 docking

5-6 April 2010 (GMT 095-096)

STS-131/19A

22,23,25 January 2012 (GMT 025)

SWx: M8.7 flare, CME ~ 2211 km/s

9-11 March 2012 (GMT 069-071)

SWx: X5.4 flare, CME ~ 2200 km/s

X1.3 flare, CME ~ 1800 km/s

23 May 2012 (GMT 144)

SpaceX Dragon berth/unberth

15-16 July 2012 (GMT 197-198)

SWx: X1.4 flare, CME ~ 1400 km/s

3 September 2012 (GMT 247)

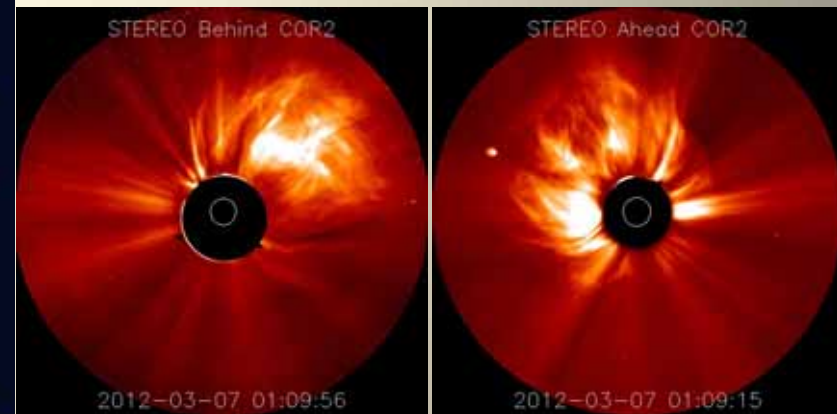
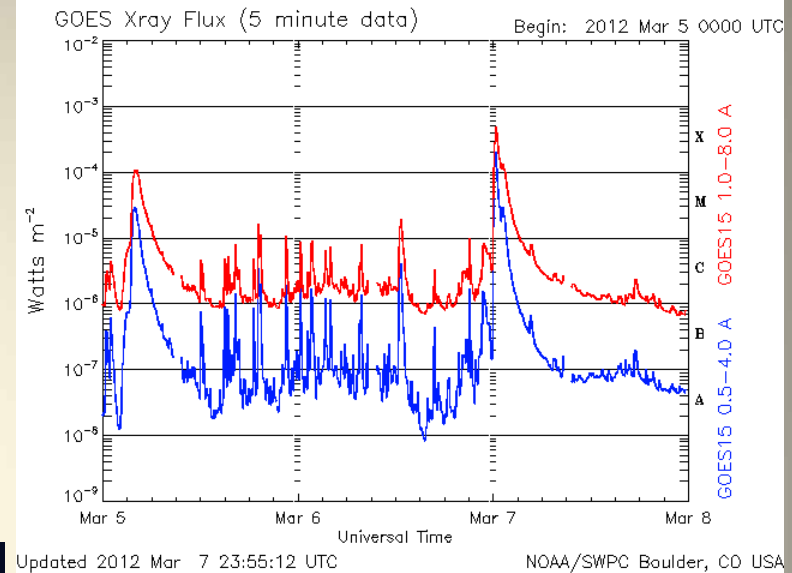
US EVA



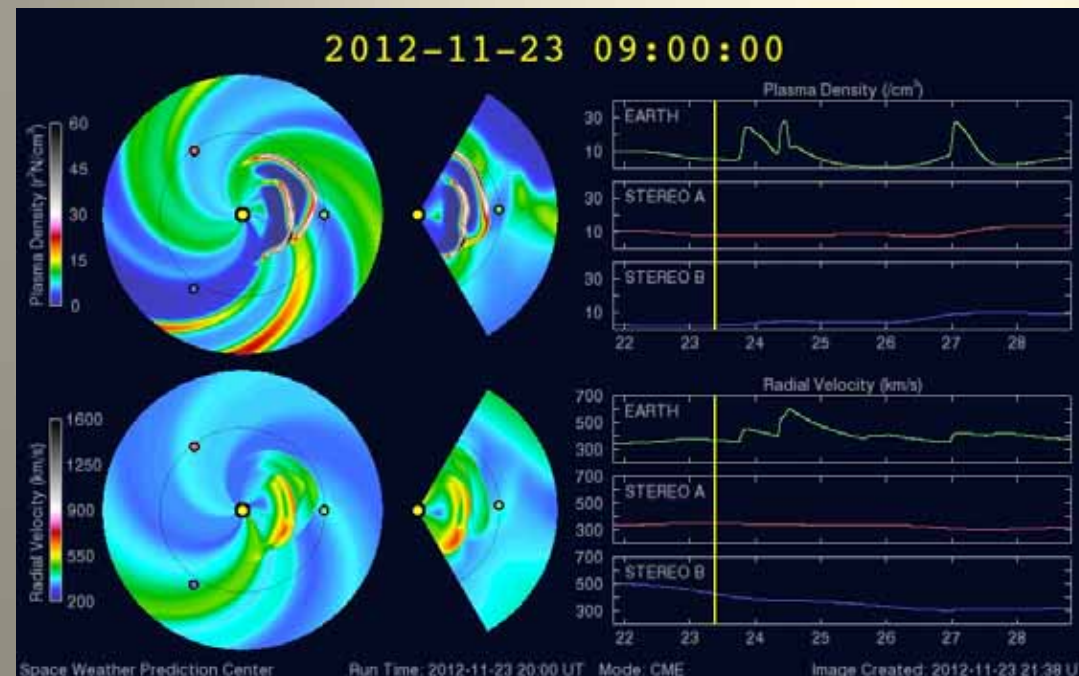
Space Weather Real Time Monitoring

Real Time Data, Modeling

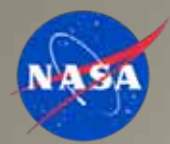
- SOHO, STEREO coronagraph images
- X-ray flare, CME image data and alerts from NOAA SWPC, GSFC SWRC, and SIDC give advanced warning of potentially geoeffective solar disturbances with lead time of ~days
- WSA-Enlil CME propagation model output from NOAA SWPC and GSFC SWRC provide independent estimates of CME arrival times at Earth



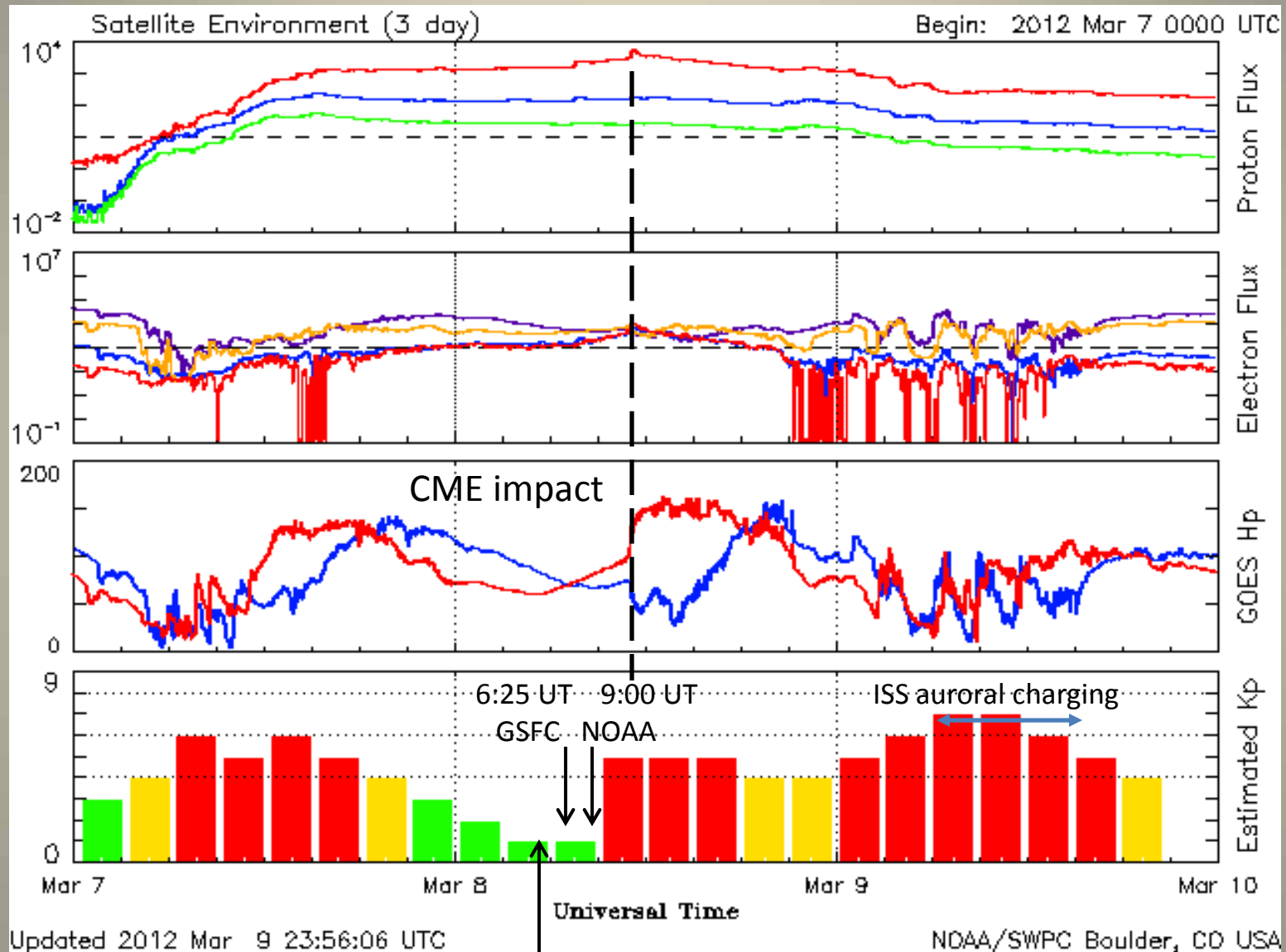
<http://stereo-ssc.nascom.nasa.gov/browse/2012/03/07/index.shtml>



<http://www.swpc.noaa.gov/rsa-enlil/>



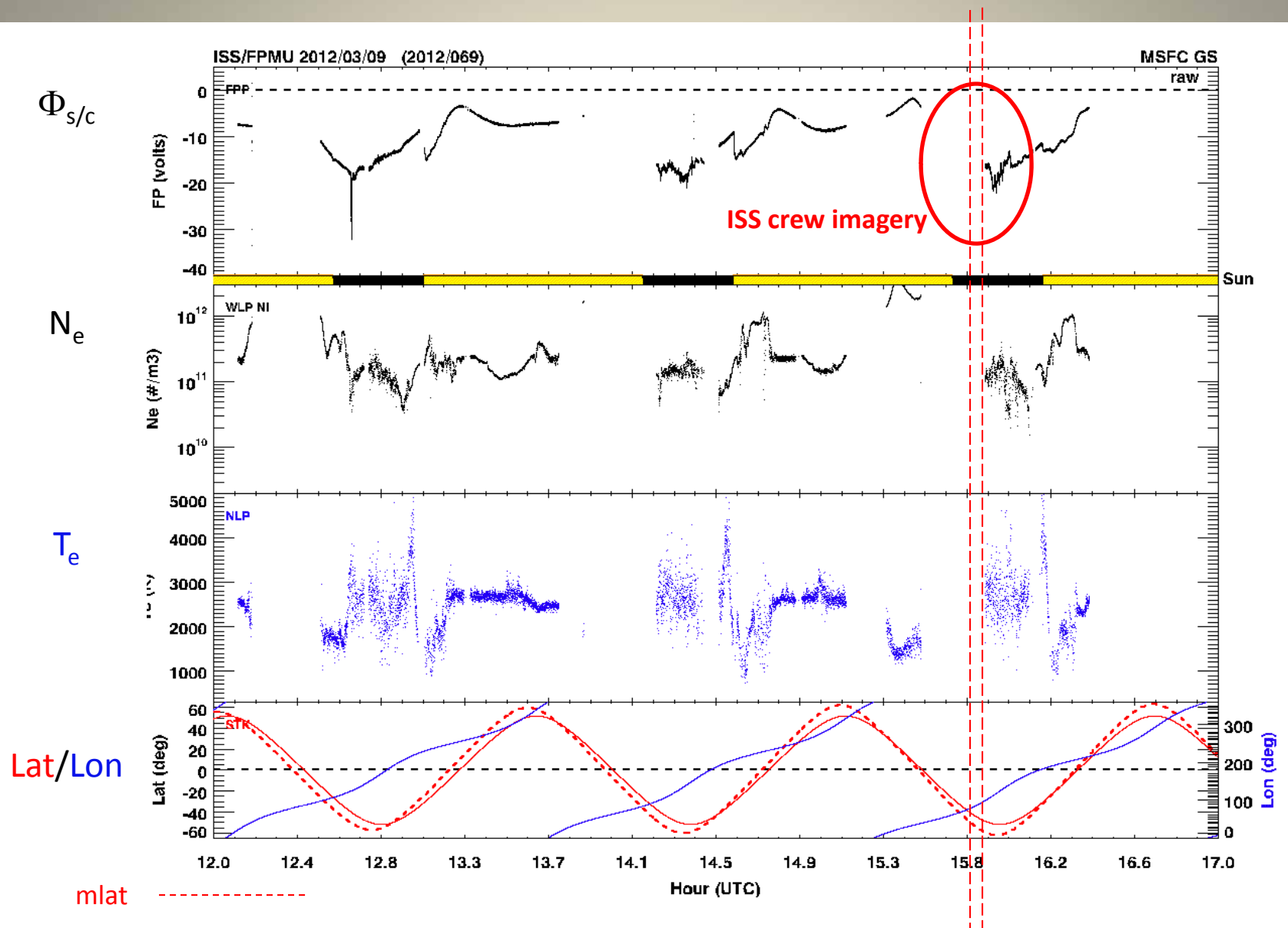
March 2012 Geomagnetic Storm



FPMU activated based on CME alerts



9 March 2012





Auroral Images

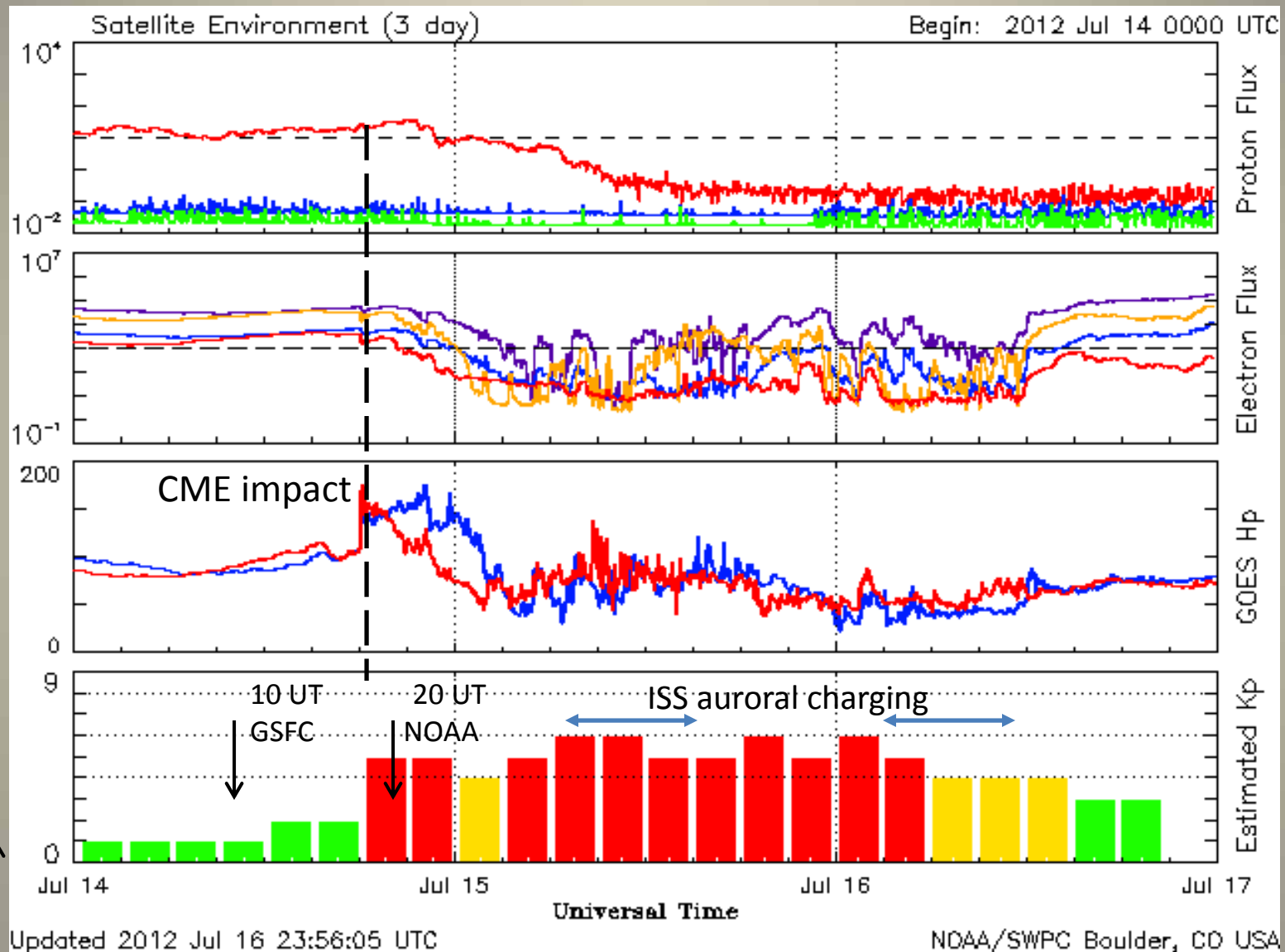
Aurora images using wide angle lens on digital camera through ISS Cupola (Don Pettit, Exp 30/31) show aurora in nadir and ahead of ISS immediately before FPMU records of auroral charging

Documents ISS passing through auroral arc!





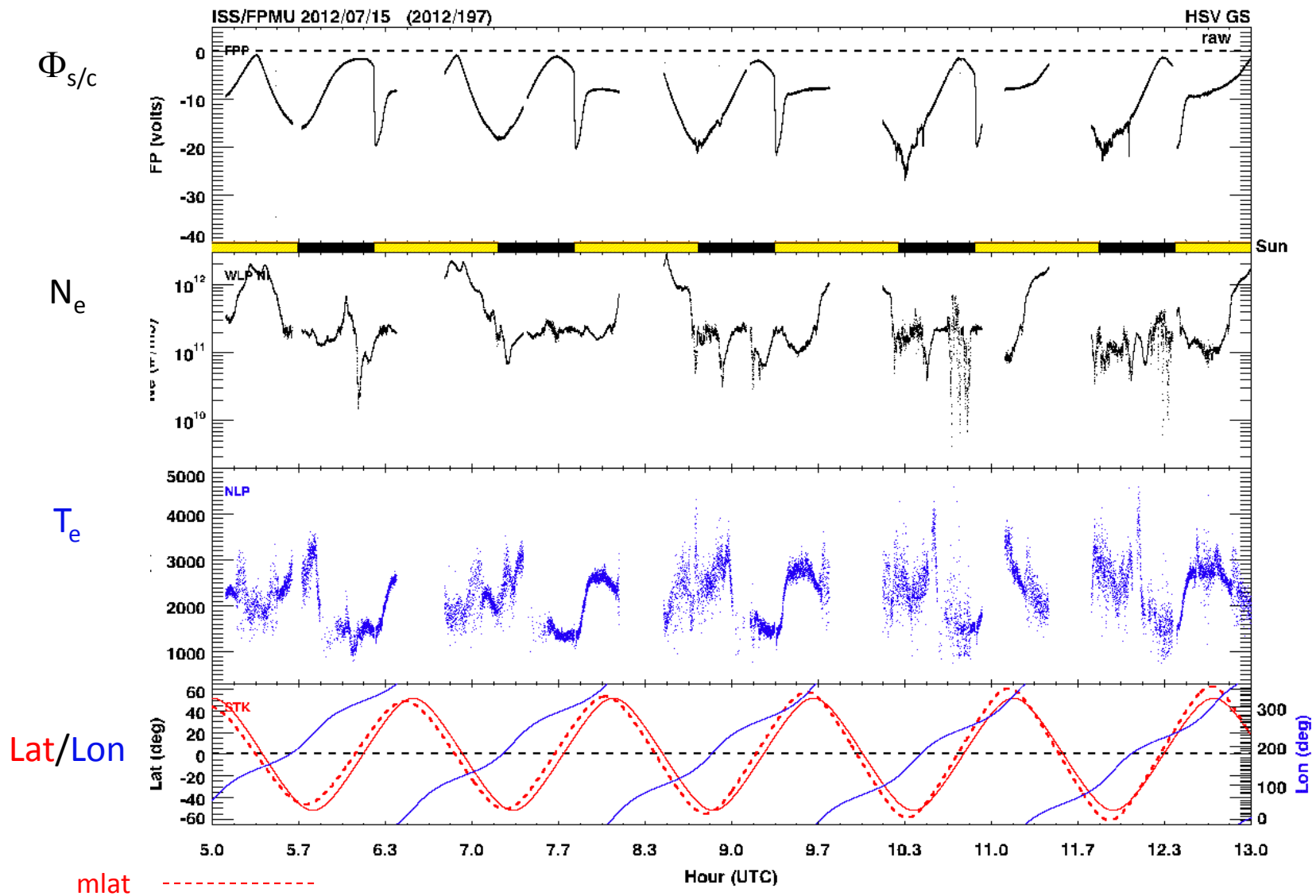
July 2012 Geomagnetic Storm



FPMU activated on 13 July based on CME alerts



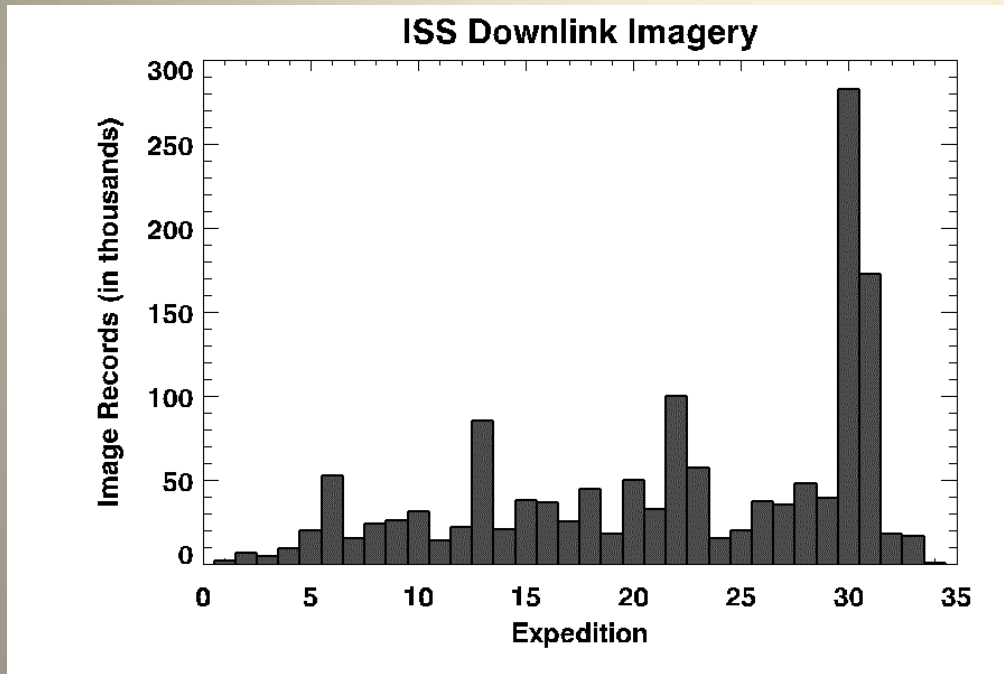
15 July 2012





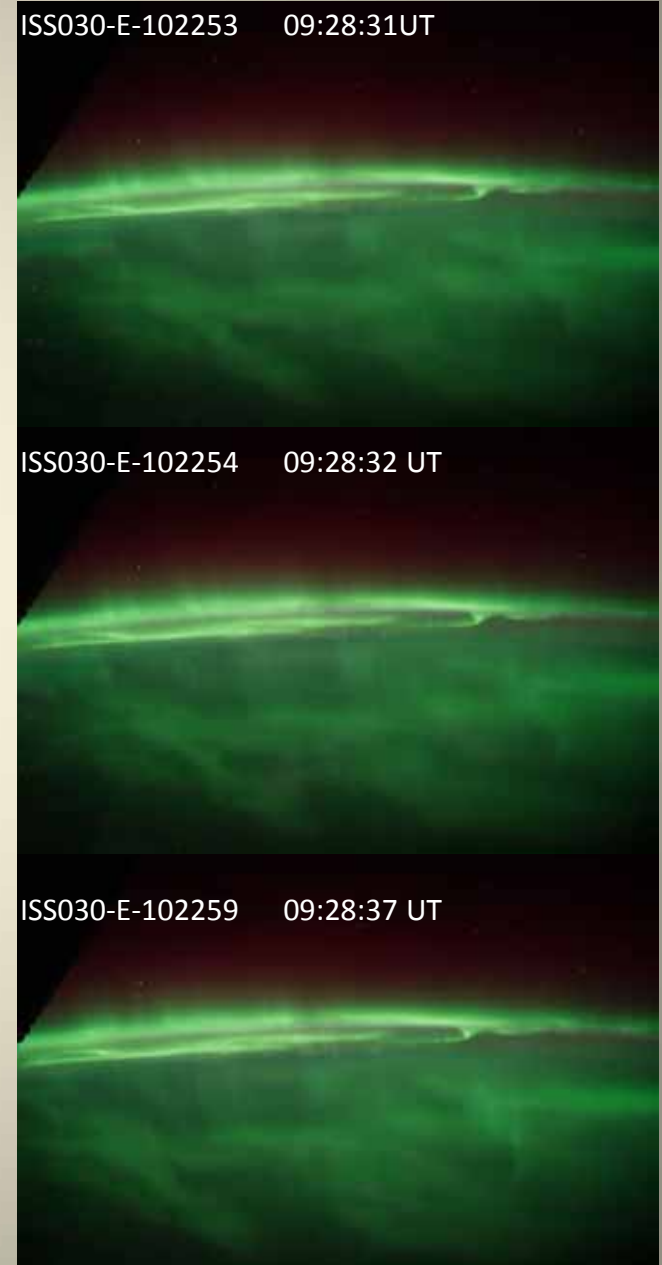
ISS Auroral Images

Don Pettit on ISS (Exp. 30/31) was notified regarding upcoming space weather events along with information on ISS orbit geometry relative to terminator boundaries to support his efforts to capture auroral images from orbit



Data source: JSC, Digital Image Management System

ISS on-orbit images: <http://eol.isc.nasa.gov/>





ISS image: 28 March 2012



ISS image: 24 April 2012



Questions?